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Preliminary Report on Research and Development Work for Parachute Assembly to be used in lowering the Instrument Section from the Meteorological Rocket Sonde NAX-12-47 (Deacon).

GENERAL TEXTILE MILLS, INC.
NEW YORK 1, NEW YORK

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LEONARD P. FRIEDER, PRESIDENT

August 12, 1948

The Chief of the Bureau of Aeronautics
Navy Department
Washington, D. C.

Attention: Airborne Equipment Section: Aer-AE-52

Subject: Preliminary Report on the Research and Development Work for the Parachute Assemblies required for the Development of a System for lowering the Instrument Section from the Meteorological Rocket Sonde NAX-12-47 (Deacon).

Dear Sir:

During the past year a great deal of interest has been expressed by the Bureau of Aeronautics of the Department of the Navy in the practicability of lowering meteorological instruments having a gross weight of 40 pounds, including a parachute, from the nose of a rocket. The descent rate desired was not to exceed 100 feet per second in the 100,000 foot altitude range. The parachute packing space was not to exceed 250 cubic inches. The theoretically preferred rate of descent was stated to be 25 feet per second but with a practical rate of 60 to 75 feet per second.

Very little was known of the technical problems to be met. The most recent data on air density is a chart which was prepared in 1926 on a theoretical basis by the Bureau of Standards. Parachute rates of descent in the ionosphere could only be computed by a ratio of the rates of descent at sea level to that at the desired altitude. This formula had probably been checked only by use of an old textbook formula. To even approach the desired rate of descent a parachute large enough for the task

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would be required to be packed in a small container under very high pressure. While we did have experience in pressure packing of parachutes, there has been no experience in the use of very high pressure packing on textile parachutes.

Negotiations on this problem with the Bureau of Aeronautics crystallized in February 1948 to the point that the Department of the Navy desired to proceed with the necessary contracts for its fulfillment. We expressed the preference to prove the proposed first phase of the parachute work before other related contracts were let. Preference was expressed by us that we proceed at once, even without a formal contract, and on verbal assurance that our action would be protected when the contracts were awarded. We did not wish to involve ourselves in a commitment for a solution based on a problem of which the technical background was so nebulous, and also to indirectly cause the Department of the Navy to commit itself to large expenditures on associated phases of the work if we could not reasonably perform on our phase.

After a very careful analysis of the problem and based on proposals we made and verbal instructions given, we manufactured and pressure packed eight (8) special parachute assemblies and forwarded them in part by messenger and in part by air express to Little Falls, Minnesota, during the month of March 1948. The units were tested under our supervision by the General Mills, Inc., at Little Falls, Minnesota, under the authority of the Office of Naval Research and the Bureau of Aeronautics. The facilities of "Skyhook" were used. These test units were given high priority and all test work was facilitated to the utmost by staff assigned by General Mills, Inc.

In order to facilitate the test work and to proceed with the utmost economy, it was agreed that in the first phase of the project, parachutes of minimum strength and packing space requirements would be carried aloft by high altitude balloons and then set free with the desired load. The parachutes were to be tracked during descent with the aid of both theodolites and photo-theodolites. In this first phase the test program would be given direction and several of the unknown characteristics of parachutes as they act in the upper atmosphere would be clarified.

The second test phase has also been proposed to be carried out with the aid of high altitude balloons in order to prove the selection of both fabric and parachute size as a result of the preliminary data obtained in the first phase.

It has been also proposed that when the results of the observations of the preceding two phases were such that certain critical parachute characteristics were known, that further test work would be done by placing the parachutes in dummy Deacon rockets. The use of dummy rockets of the type to be used ultimately would permit the adjustment of the strength of the parachutes to the requirements of the task.

Inasmuch as little was known of the way parachutes function at very high altitudes, each unit was selected to answer the greatest number of technical questions.

1. Silk, Fortisan Rayon, and Nylon of different constructions were alternate materials selected to determine if atmospheric conditions in the ionosphere would cause a delay in parachute opening on particular fabrics. -- All materials worked equally well within the altitude range tested, and there was no indication of differences in rate of parachute openings due to materials used.

2. Fabrics with low as well as high air permeabilities were used. The range covered was 140 minimum to 700 maximum. (Air permeability is measured as the number of cubic feet of air passing through the fabric per square foot of surface at 1/2" difference in water pressure.) This phase of the testing was to determine the maximum air permeability which could be used and still accomplish a fast opening in the thin air of the ionosphere. The results of the test indicate that parachutes made of silk of 340 air permeability and silk of 700 air permeability open equally fast.

   Our experience indicates that high air permeability fabrics induce a lower opening shock on the attached load than do low air permeability fabrics. High air permeability fabrics may be made light in weight and thus less packing space is required.

3. Fabrics of different weights and construction were used as a measure of buoyancy as well as of air permeability.

4. All parachutes were initially packed at our factory under a pressure of 600 pounds per square inch. High pressure packing is a necessary

phase of the problem due to the limited space available. It is also a requirement that the parachute be packed in a sealed container or capsule at the factory. The container may then be inserted into the nose of the rocket in the field of operations. Our prior experience and the results of these tests indicate that high pressure packing is practical.

5. It was required that the parachute should not oscillate despite variable and high wind conditions. The nylon parachute of 140 air permeability (this was the lowest air permeability tested) was reported as oscillating slightly. The high air permeability fabrics made of silk in the 340 and 700 range were observed to be stable despite high wind conditions. Remarks as to oscillation were the result of observing the parachute during descent through a ground stationed theodolite.

6. Parachute Construction. All the parachutes tested were made to minimum strength requirements. This practice was followed on the test in order to save packing space, and it was felt that if a high air permeability, light weight fabric did perform satisfactorily, there would be space remaining to permit the necessary reinforcements being added to meet actual service requirements. Service requirements, such as the speed of the rocket at the time of ejection of the parachute, were not known.

Inasmuch as the high air permeability fabrics did meet the functional requirements of the test, it is now thought that the structure can be reinforced to meet anticipated service needs and still remain within the 250 cubic inch space allotted. The lightest weight fabric required only 197 cubic inches packing space in its stripped design.

7. All of the parachutes were packed in a well insulated chamber. It was anticipated that in service the compartment would be heated by air friction on the nose of the rocket. In these tests the parachute ascent was at a slow rate through very low temperature atmosphere. Two to three hours was required for the ascent.

8. Drag Co-efficient. It was desired also to check drag co-efficients of parachutes of various air permeabilities to determine whether the drag co-efficient determined under standard air conditions at sea level by the National Advisory Committee for Aeronautics would hold in the thin air of the ionosphere. It was interesting that the rates of descent did bear a satisfactory relationship to the wind tunnel tests.

9. Rate of Descent. The tests indicate that any of the 24 foot diameter Baseball Hemispherical Parachutes used will give a rate of descent with a 40 lb. gross load, including the weight of the parachute, within the limits specified to us by the technical sections of the Bureau of Aeronautics.

It was determined that the formula which we commonly use for computing the rate of descent of parachutes thru various air densities is correct within practical limits--namely, that the rate of descent is proportional to the square root of the inverse of the air densities.

10. The appended chart presents the rate of descent in feet per second versus altitude for each of the parachute units which were tracked; there is also presented a comparative line showing the theoretical

rate of descent at various altitudes for the Baseball parachute having an air permeability of approximately 200. The rate of descent formula used to compute this curve was based on field test data under various atmospheric and load conditions. The rate of descent would, of course, vary with the drag co-efficient of the parachute in accord with the studies made by the National Advisory Committee for Aeronautics on BASEBALL parachutes of various air permeabilities. This chart is made part of this report.

Eight (8) different parachutes and assemblies were submitted by General Textile Mills, Inc. for evaluation; five (5) of the parachutes were tracked on descent and the other three (3) were lost due to premature explosion of the balloons by which they were carried or by the unit having drifted far out of range, or by fouling in the balloon launching lines.

11. Based upon a reasonable interpretation of the data and visual observation thru theodolites and also photo-theodolites of the time required for full deployment after release, full deployment was accomplished during descent of between 700 and 800 feet. This result was far better than had been anticipated. Only one balloon used for the ascent reached the desired and anticipated altitude of 100,000 feet or more. All of the other balloons failed to attain that altitude for one technical reason or another. Two units ascended to over 87,000 feet.

This report is preliminary. The information has been obtained only as a guide for future tests. The variety of materials selected for the construction of the parachutes as well as the weight of the materials and their air permeabilities were designed to cover a broad range in order to indicate the direction in which the next phase of the testing should proceed.

Summary and Recommendation

Our conclusion is that on the next series of tests ten (10) parachutes should be made, five (5) of which should be of 0.34 oz. per sq. yd. silk and five (5) should be made of 0.54 oz. per sq. yd. silk. While the 0.34 oz. silk has a low packing volume, it may have had a slightly higher rate of descent than the 0.54 oz. silk, but inasmuch as only one of each unit was tracked in descent, the information is only indicative and further studies are required. Neither of these two parachutes oscillated. They were both very stable. It may develop that the 0.54 oz. silk has a lower rate of descent for the same size parachute so that while the 0.54 does take more packing volume than the 0.34 oz., it may be possible to use a smaller parachute.

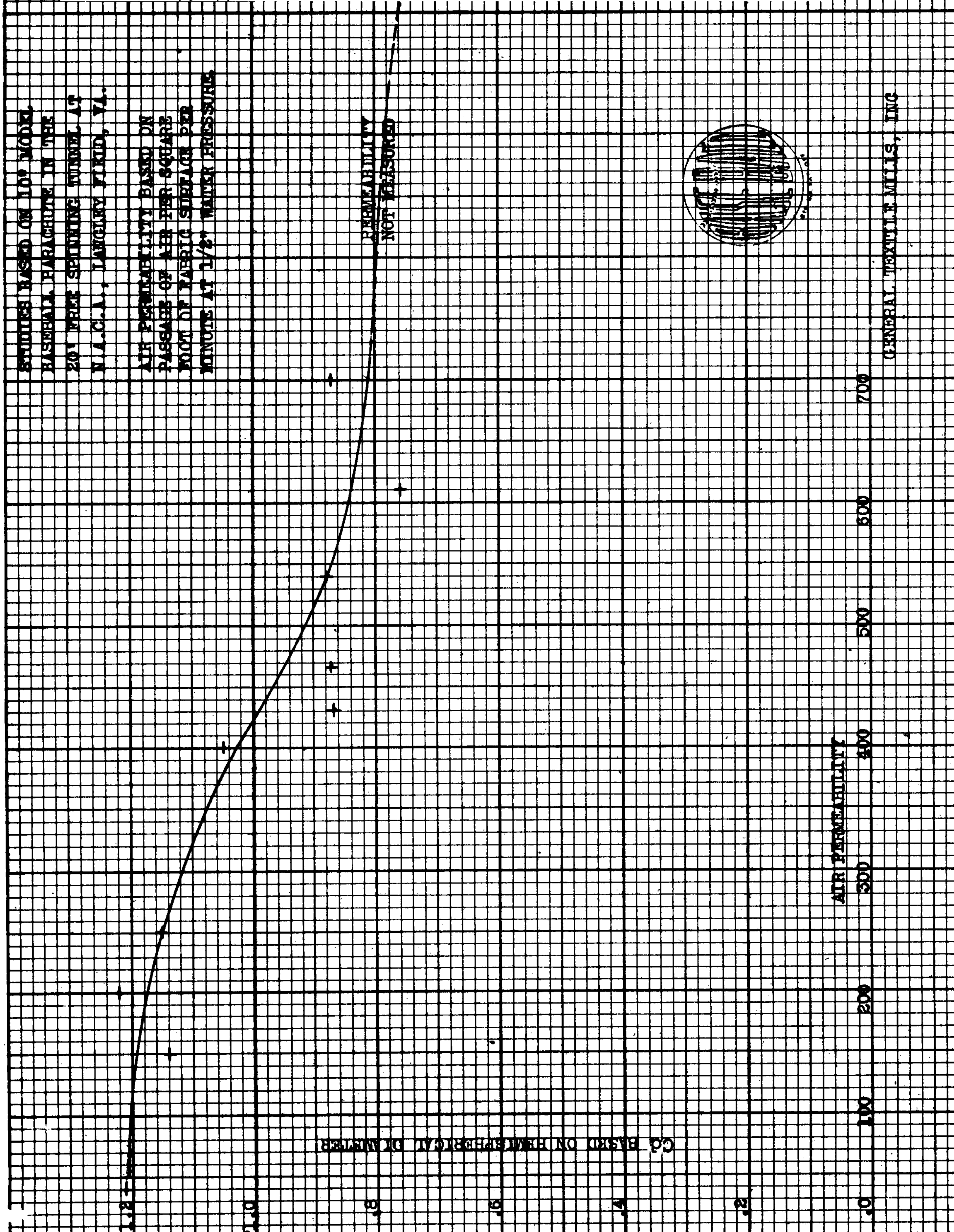
After the next balloon ascension evaluation tests are made, the parachutes should be tested in a rocket without aerological instruments in the nose. This test would determine what reinforcements are necessary to meet the structural requirements of the task assigned on this Rocket Sonde program NAX-12-47.

Very respectfully submitted,

GENERAL TEXTILE MILLS, INC.

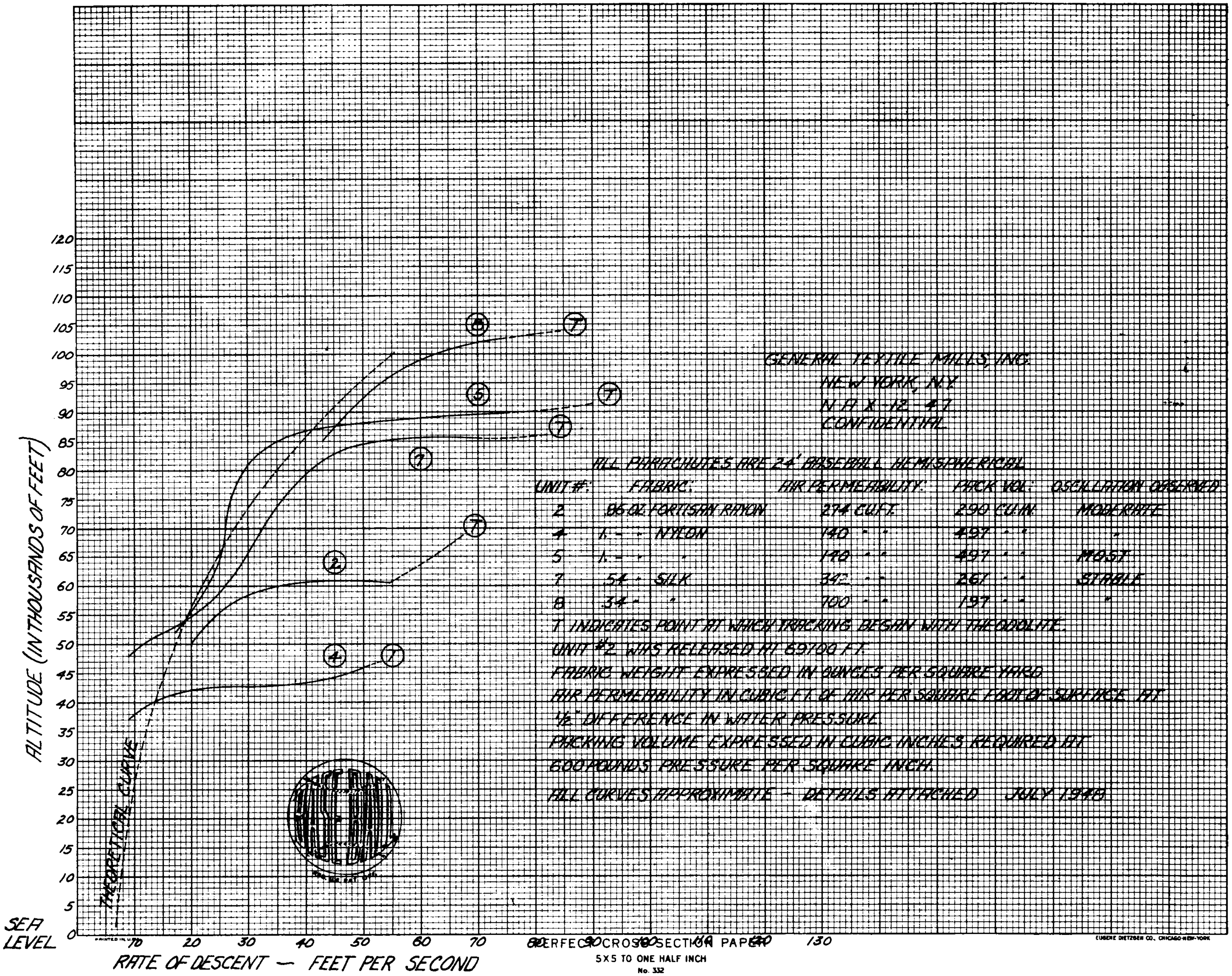
Leonard P. Frieder

Leonard P. Frieder
President



Subject: BASEBALL PARACHUTE
DRAG STUDIES (PRELIMINARY)
MADE IN 20' TUNNEL - N.A.C.A.

Date: Jan. 1948



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Theoretical rates of descent at various altitudes in comparison with a sea level rate of descent with a 40 pound load, including the weight of the parachute.

The formula used for rate of descent is:

$$\text{Rate of descent in feet per second} = 25.\sqrt{\frac{\text{Load in pounds (W)}}{\text{Diameter of the Baseball Hemispherical Parachute in feet (D)}}} = 25.\sqrt{\frac{W}{D}}$$

The rates of descent at altitudes above sea level have been adjusted to the square root of the inverse of the air densities at the different levels. The computation is made to the nearest whole number. The base formula used was itself determined from the average of many service tests under different atmospheric and load conditions.

Altitude (Feet)	Rate of Descent Feet per Second
100,000	56.
90,000	44.
80,000	35.
70,000	27.
60,000	22.
50,000	17.
40,000	13.
30,000	11.
20,000	9.
10,000	8.
5,000	7.1
Sea level	6.5

TEST DATA ON UNIT NO. 2

This parachute is a 24 foot diameter BASEBALL Hemispherical parachute and made of 0.86 oz. per square yard Fortisan rayon which had an air permeability of 274.

The unit was packed under pressure of 600 pounds per square inch; its volume at the time of packing was 290 cubic inches.

Altitude (Feet)		Rate of Descent Feet per Second
69,700	Parachute released	
60,400	Tracking began with one Theodolite	54.1
59,500		37.5
58,200		27.0
57,000		25.0
55,800		25.0
54,700		22.9
53,600		22.9
52,500		22.9

The rate of descent in feet per second was obtained by determining the actual amount of fall during consecutive 12 second periods. The average rate of fall over four such periods is given on this table and is plotted on the charts at the average altitude of the four reading points, except that the first eight readings were taken at intervals of six seconds instead of twelve seconds.

TEST DATA ON
UNIT NO. 4

This parachute is a 24 foot diameter BASEBALL Hemispherical parachute and made of 1.10 oz. per square yard ripstop nylon which had an air permeability of 140.

The unit was packed under pressure of 600 pounds per square inch; its volume at the time of packing was 497 cubic inches.

Altitude (Feet)		Rate of Descent Feet per Second
46,500	Parachute released	
45,400	Tracking began with two photo-theodolites and one theodolite	45.8
44,400		41.6
43,100		27.1
42,100		20.8
41,300		16.6
40,600		14.5
40,600		12.5
39,500		10.4
39,000		10.4
38,400		12.5
38,000		8.3
37,500		10.4
37,000		10.4
36,600		8.3

The rate of descent in feet per second was obtained by determining the actual amount of fall during consecutive 12 second periods. The average rate of fall over four such periods is given on this table and is plotted on the charts at the average altitude of the four reading points, except that the first eight readings were taken at intervals of six seconds instead of twelve seconds.

TEST DATA ON UNIT NO. 5

This parachute is a 24 foot diameter BASEBALL Hemispherical parachute and made of 1.10 oz. per square yard ripstop nylon which had an air permeability of 140.

The unit was packed under pressure of 600 pounds per square inch; its volume at the time of packing was 497 cubic inches.

Altitude (Feet)		Rate of Descent Feet per Second
91,500	Parachute released	
89,600	Tracking began with two photo-theodolites and two theodolites	79.1
		45.8
88,500		33.3
87,700		35.3
86,000		31.2
84,500		31.2
83,000		29.1
81,600		31.2
80,100		27.1
78,800		29.1
77,400		29.1
76,000		27.1
74,700		25.0
73,500		27.1
72,200		25.0
71,000		25.0
69,800		27.1
68,500		25.0
67,300		25.0
66,100		25.0
64,900		25.0
63,700		22.9
62,600		25.0
61,400		22.9
60,300		22.9
59,200		20.8
58,200		20.8
57,200		20.8
56,200		20.8
55,200		18.7
54,300		18.7
53,400		16.6
52,600		16.6
52,000		

The rate of descent in feet per second was obtained by determining the actual amount of fall during consecutive 12 second periods. The average rate of fall over such periods is given on this table and is plotted on the charts at the average altitude of the four reading points, except that the first twelve readings were taken at intervals of six seconds instead of twelve seconds.

TEST DATA ON
UNIT NO. 7

This parachute is a 24 foot diameter BASEBALL Hemispherical parachute and made of 0.54 oz. per square yard pure silk fabric which had an air permeability of 342.

The unit was packed under pressure of 600 pounds per square inch; its volume at the time of packing was 261 cubic inches.

Altitude (Feet)		Rate of Descent Feet per Second
87,000	Parachute released	
85,400	Tracking began with three photo-theodolites	66.7
84,200		50.0
82,200		41.7
80,600		33.3
79,100		31.2
77,200		39.5
75,500		35.4
73,900		33.3
72,200		35.4
70,600		33.3
69,100		31.2
67,600		31.2
66,200		29.1
64,800		29.1
63,400		29.1
62,000		29.1
60,700		27.1
59,500		25.0
58,400		22.9
57,300		22.9
56,300		20.8
55,300		20.8
54,300		20.8
53,400		18.7
52,600		16.6
51,900		14.5
51,200		14.5
50,600		12.4
50,100		10.4
49,600		10.4
49,100		10.4

The rate of descent in feet per second was obtained by determining the actual amount of fall during consecutive 12 second periods. The average rate of fall over four such periods is given on this table and is plotted on the charts at the average altitude of four reading points, except that the first eight readings were taken at intervals of six seconds instead of twelve seconds.

GENERAL TEXTILE MILLS, INC.

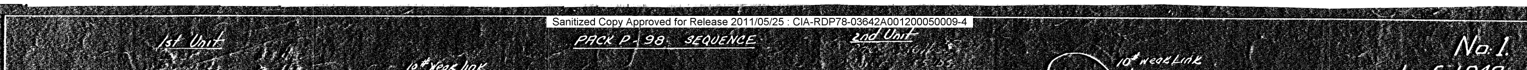
TEST DATA ON
UNIT NO. 8

This parachute is a 24 foot diameter BASEBALL Hemispherical parachute and made of 0.34 oz. per square yard pure silk fabric which had an air permeability of 700.

The unit was packed under pressure of 600 pounds per square inch; its volume at the time of packing was 197 cubic inches.

Altitude (Feet)		Rate of Descent Feet per Second
104,550	Parachute released	
102,600	Tracking began with one photo-theodolite	76.1
100,900		66.4
99,450		56.7
98,100		52.8
96,950		44.8
95,750		46.9
94,450		50.8
92,900		60.5
91,300		62.5
90,750		43.0
88,600		44.8
87,450		44.8
86,200		48.7
85,100		46.9

The rate of descent in feet per second was obtained by determining the actual amount of fall during consecutive 12 second periods. The average rate of fall over four such periods is given on this table and is plotted on the charts at the average altitude of the four reading points, except that the first eight readings were taken at intervals of six seconds instead of twelve seconds.



Fabric	Weight in oz. per sq. yd	Air Permeability	Max. pressure 600# per sq. inch	Packing Volume in cu. in.	Wgt. in lbs. of complete parachute	1st Unit Half: Wgt. in lbs. of container	1st Unit Half: Load attached in lbs.	2nd Unit Half: Wgt. in lbs. of container	2nd Unit Half: Load attached in lbs.
Fortisian Rayon	.86	274	6" dia x $10\frac{1}{4}$"	290	7.9	3.5	28.6	19.5	12.6
Rip stop Nylon	1.1	140	$6\frac{1}{2}$" x 15"	497	9 -	3.5	27.5	19.5	11.5
Silk	.54	342	6" x $9\frac{1}{4}$"	201	5.3	3.5	31.2	19.5	15.2
Silk	.34	701	$5\frac{1}{4}$" x $8\frac{3}{4}$"	197	3.75	3.5	32.75	19.5	16.75
		①			②				

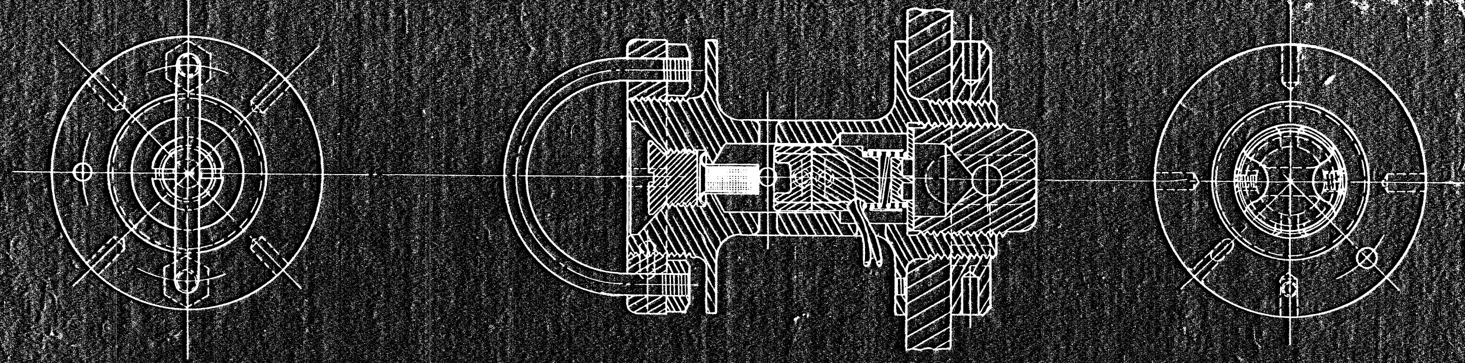
① Air Permeability: Cubic feet of air per square foot at $\frac{1}{2}$" water pressure.
② Parachute and shroud lines only.
③ Final 'Flight Weight' 40# in ALL cases - this includes Parachute complete and Attached Load.

GENERAL TEXTILE MILLS, INC.
NEW YORK, N.Y.

PACK P-98
PACKING METHOD.

Scale: None
Date: 1-10-49
Drawn by: P.K. Traced L.P.
Checked by: J.A.A.
Approved:

Appr. Stand Practice Control: [signature]



Fabric	Weight in oz. per sq yd	Air Permeability	Max pressure 300# per sq inch	Packing Volume in cu inch	Wt. in lbs. of complete Parachute	1st Unit Half		2nd Unit Half	
						Wt. in lbs. of Container	Load attached in lbs.	Wt. in lbs. of Container	Load attached in lbs.
Fortisan Rayon	[illegible]	214	6" dia x 10¼"	290	7.9	3.5	28.6	19.5	12.6
Rip Stop Nylon	1.1	140	6½" x 15"	497	9.–	3.5	27.5	19.5	11.5
Silk	.54	342	6" x 9½"	261	5.3	3.5	31.2	19.5	15.2
Silk	.34	101	5½" x 8½"	191	3.75	3.5	32.75	19.5	16.75
		(1)			(2)				

(1) Air Permeability: Cubic feet of air per square foot at ½" Water pressure.
(2) Parachute and shroud lines only.
(3) Final flight Weight 40# in ALL cases - this includes Parachute complete and attached load.

Appr. Stand Practice:
Control:

REVISIONS	
NO.	DATE	BY

GENERAL TEXTILE MILLS, INC.
NEW YORK, N. Y.

PACK P-98
ELECTRONIC PACK OPEN. RELEASE.

SCALE None
DATE 8-3-49
DRAWN BY Pk Traced L.P.
CHECKED BY
APPROVED